

## **Middleware Evaluation and Benchmarking for Use in Mission Operations Centers**

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### **Focus Issues**

- Emerging ground system technologies
- Communication architectures

## Abstract

Middleware technologies have been promoted as timesaving, cost-cutting alternatives to the point-to-point communication used in traditional mission operations systems. However, missions have been slow to adopt the new technology. The lack of existing middleware-based missions has given rise to uncertainty about middleware's ability to perform in an operational setting. Most mission architects are also unfamiliar with the technology and do not know the benefits and detriments to architectural choices – or even what choices are available.

We will present the findings of a study that evaluated several middleware options specifically for use in a mission operations system. We will address some common misconceptions regarding the applicability of middleware-based architectures, and we will identify the design decisions and tradeoffs that must be made when choosing a middleware solution.

The Middleware Comparison and Benchmark Study was conducted at NASA Goddard Space Flight Center to comprehensively evaluate candidate middleware products, compare and contrast the performance of middleware solutions with the traditional point-to-point socket approach, and assess data delivery and reliability strategies. The study focused on requirements of the Global Precipitation Measurement (GPM) mission, validating the potential use of middleware in the GPM mission ground system. The study was jointly funded by GPM and the Goddard Mission Services Evolution Center (GMSEC), a virtual organization for providing mission enabling solutions and promoting the use of appropriate new technologies for mission support.

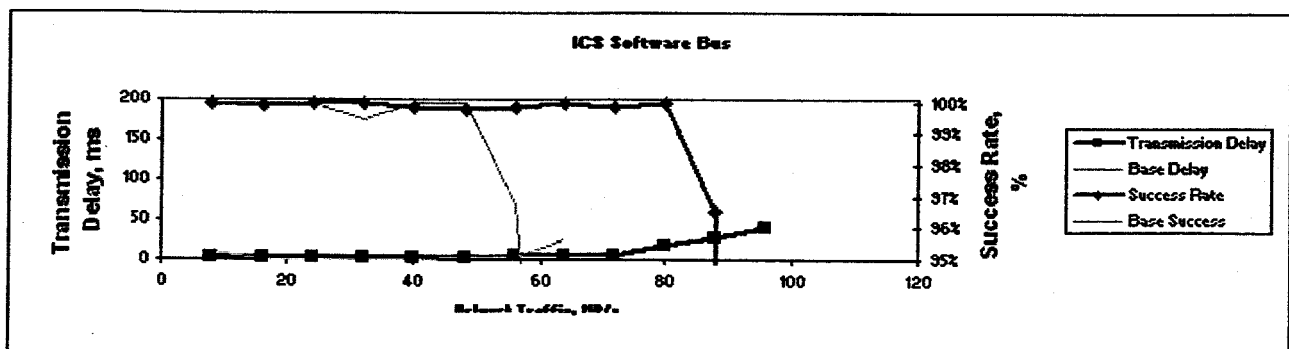
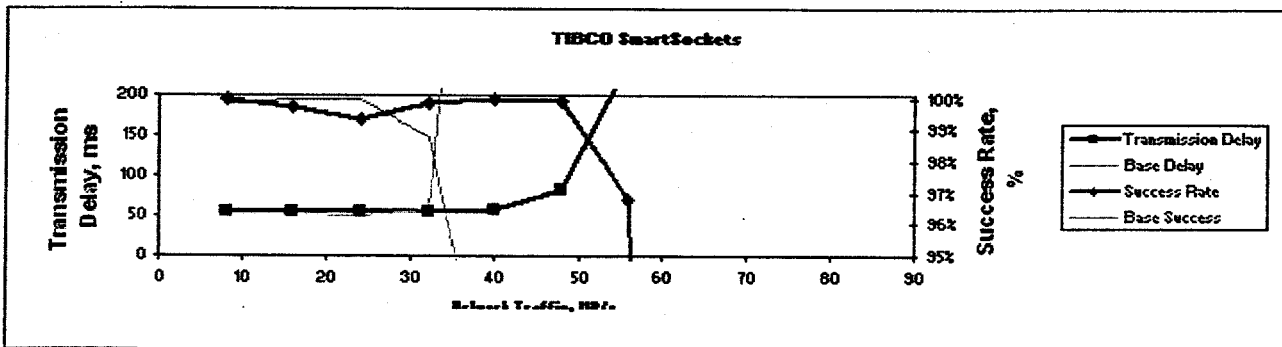
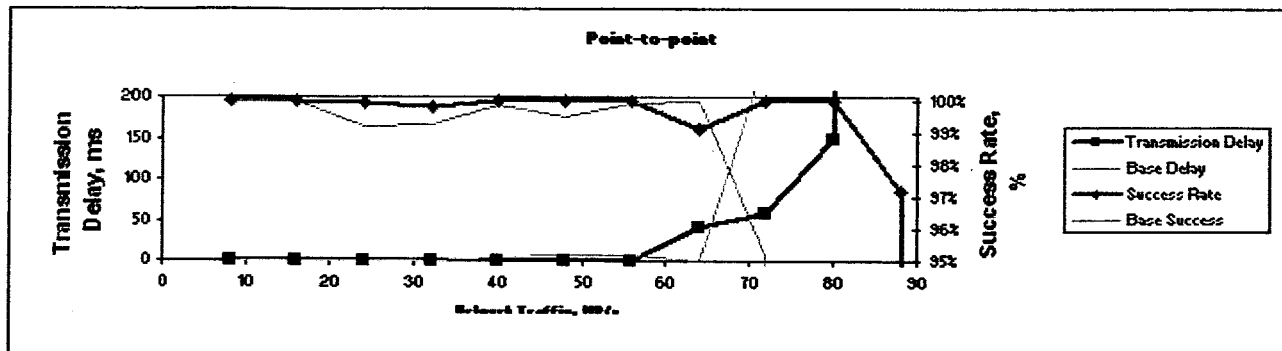
The study was broken into two phases. To perform the generic middleware benchmarking and performance analysis, a network was created with data producers and consumers passing data between themselves. The benchmark monitored the delay, throughput, and reliability of the data as the characteristics were changed. Measurements were taken under a variety of topologies, data demands, and data characteristics, using several middleware products. All results were compared to systems using traditional point-to-point socket communication. By comparing performance results under different settings, inferences could be made about each middleware's ability to meet certain requirements of the GPM mission.

The second phase simulated a middleware-based mission operations center. Actual mission support tools were either used or simulated to create real world demands on the middleware. Network and computer demands were watched closely to verify that no specific idiosyncrasies of mission operations activities would prove unsupportable by the middleware.

In our presentation, we will address some commonly accepted misconceptions concerning middleware in mission support architectures. Specifically, we will focus on the perception that middleware solutions are too slow or impose too much overhead for real-time mission operations, and that middleware solutions are too expensive for small

missions. We will also examine unrealistic expectations regarding the autonomy and capability of middleware. Additionally, we will propose a decision process for missions to follow in constructing a middleware-based solution, including selection of a commercial middleware product, allocation of communication smarts to the middleware or the client, use of guaranteed messages and redundant systems features, fine tuning of packet sizes and network demands, and identification of hardware requirements.

We will also show the complete findings of the middleware study in the form of performance charts such as those shown below. These generic charts would be useful to any mission making choices about middleware.



The following charts show performance for each of the middlewares. The blue shows average end-to-end transmission time of messages as network on the load increases. The red shows message reliability as the load increases. These simulations were run using 6 clients, 2 on each of 3 windows PCs, all sending 5K messages. Each data point represents 5 minutes of simulation.

The dark blue and red are from a simulation that broadcast the message to all other clients. The light blue and red only sent the message to two other clients.